A Utah bridge team turns to structural steel solutions for expanding an Interstate crossing to accommodate high-occupancy vehicle lanes.

HIGH Volume, LOW Impact

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◀ The sliding system involved an end diaphragm with the stainless steel slide shoe on Teflon bearing pads.

▲ The permanent abutment between the temporary abutments provided a level sliding path.

AS UTAH'S ONLY north-south Interstate, I-15 is critical to the state's infrastructure.

Average annual daily traffic in 2012 was approximately 65,000 vehicles in each direction and is predicted to rise to over 80,000 by 2040. To brace for this increase and help address the potential for the delays it would likely incur, the Utah Department of Transportation (UDOT) has implemented systematic capacity improvements through the addition of high-occupancy vehicle (HOV) lanes in the Salt Lake City vicinity.

One prominent interchange where HOV lanes were recently implemented is the I-15–Hill Field Road interchange located 25 minutes north of Salt Lake City. A pair of existing three-span bridges carried the I-15 traffic while local traffic moved along Hill Field Road below. The goal of the project was to provide additional structure width for HOV lanes as well as to upgrade the intersection to a single-point urban interchange (SPUI) configuration. This configuration allows large volumes of traffic to move through limited space by providing multiple turning movements below the bridges while high-volume traffic flows on I-15 above.

Using the design-build method, the design and construction team believed that building the new substructure behind the existing bridge abutments, then sliding the superstructures into place would be the most cost-effective and least disruptive approach. The construction would take place in three phases and maintain three lanes of I-15 traffic in each direction by using the southbound bridge as a "shoofly" (a solution in which an existing bridge is temporarily used as a detour in both directions).

▼ The southbound bridge was used as a shoofly while the northbound bridge was slid into its final position.

▼ The new superstructures were built next to the existing ones.

Wing wall construction, following the slide.

The prestressing resistance anchor block used in the slide.

The project came with challenging construction requirements:

- The existing bridges were three spans, each 56 ft wide. Clearances over Hill Field Road to the bottom of girders were substandard
- Lowering the Hill Field Road profile would require extensive utility (storm and water line) relocations, create new drainage issues and require more roadway reconstruction
- The RFP allowed only two full 12-hour closures of each direction of I-15. Additional full or partial closures would be charged to the contractor at $20,000 per lane per hour
- Hill Field Road was allowed only 12 off-peak, 12-hour full closures, with ramps used to maintain I-15 traffic during that time. Any additional full or partial closures would be charged to the contractor at $10,000 per lane per hour

Sliding Solution

The team explored multiple accelerated bridge construction (ABC) concepts. Sequential phasing of the superstructures was immediately ruled out due to strict maintenance of traffic (MOT) requirements and closure constraints. Self-propelled modular transporters (SPMTs) were also examined but ended up not being cost-effective or convenient when considering the grading that would need to occur to accommodate the new interchange configuration. However, as the new structures were adjacent and similar in geometry, a third ABC concept—bridge sliding—proved to be a winner and was selected based on estimated completion time, feasibility and cost.

Temporary pile-founded abutments would be driven adjacent to either side of the existing structures and connected to future permanent pile-founded abutments, which were to be built once the existing structure was removed. This long continuous section of temporary and permanent abutments would be the level surface that would support the superstructure during the slide. The wider typical section of the new bridges allowed for part of the permanent abutments to be used in the temporary construction location. The southbound superstructure (in the temporary location) would carry I-15 traffic in a shoofly condition while the existing structures could be removed.

Once the shoofly was in place, the existing bridges could be removed, the northbound bridge would be slid into place and all traffic would move to the northbound structure. Finally, the southbound bridge would be slid into place, approaches would be completed and the remaining civil work could occur. The temporary abutments would then be removed prior to substantial completion.

Slide Shoes

To move the superstructure, the team employed two, 13-ft-long concrete blocks with polished stainless steel surfaces at the bottom of each end diaphragm. These shoes would slide on Teflon bearing pads, with the superstructure pulled by prestressing jacks at each abutment line. The Teflon pads had a lubricated coefficient of friction of about 5% during the slide and were replaced with permanent bearing pads in the final location.

The team initially considered a prestressed concrete solution, but this would have required a two- span bridge and a bent that would be overly expensive to build. This approach would also have increased user cost penalties thanks to the additional lane closures needed to construct a pile cap, columns and bent cap. It would also increase the overall length of the structure to accommodate the SPUI configuration. Overall, an equivalent concrete option for this project would have weighed 437.5 tons more and required a structure that was 3 ft deeper.

All of these considerations led the team to select a single-span steel superstructure. Steel allowed for a shallow girder section that closely matched the existing structure depth. The I-15 northbound and southbound profiles matched the existing profiles at the bridges, which minimized expensive interstate roadway reconstruction. The Hill Field Road profile was lowered only 2 ft; this was 2 ft less than what the RFP concept plans called for and required fewer utility relocations. Plus, the lightweight single-span steel solution was simply easier and quicker

to slide. A single span meant one less temporary support, thus reducing traffic interference when shifting lanes under the new and existing structures.

Due to vertical clearance requirements, the northbound bridge was built 2 ft higher than the final condition. This provided temporary clearances that would ensure the new steel girders would not be damaged by over-height vehicle traffic below the bridge prior to the bridge slides. Once again, the single-span solution proved beneficial, as it simplified lowering the structures.

Fast Start

The schedule dictated that the project needed to be substantially completed by August 1, 2016, and the design and construction schedules had to be coordinated to allow lead time when ordering materials, particularly the steel girders. The design team provided an early steel package one month after the notice to proceed (NTP) to allow for the 12-week fabrication time. Complete bridge plans were released for construction by mid-July 2015, just three months after the NTP.

Pile driving for the temporary abutments began immediately. The end diaphragms with slide shoes were formed on the temporary abutments, girders were set on these end diaphragms and both superstructures were complete by September. As the southbound bridge functioned as a shoofly, northbound and southbound lane capacity was maintained, avoiding work through the winter.

On March 9, 2016, one year after design began, the I-15 northbound bridge was scheduled to be moved into place. Preparations began several weeks earlier with the removal of the existing structures and placement of permanent piling and pile caps. Several days prior to the slide, prestressed cable was threaded through the end diaphragm blockouts.

The day of the slide, the northbound structure was lowered 2 ft onto sliding pads and Hill Field Road was closed to traffic. The horizontal movements began at midnight and the 1,600-ton bridge—both bridge spans are 178.5 ft long—was slid 74 ft in five hours. (Also, these girders were fabricated and erected at full length, thus avoiding the need for field-bolted splices.) Following the slide, earthwork and approach wingwalls were constructed.

On May 1, the second bridge slide was completed, following the same principles. The team switched to hardwood, instead of the more compressible plywood, to support the Teflon slide bearings. They also tensioned the prestressing strands more uniformly for smoother jack advancement. These improvements, along with the crew's familiarity with the system, resulted in a slightly faster completion time for the second slide. Wing walls, approach slab construction, backfill and civil work associated with the second bridge were delayed due to a wet spring season. Despite the complications, the project opened to traffic by the end of August.

Thanks to the design-build process and the ABC component of bridge sliding, the team was able to work together to optimize construction. And for this project (and many others) steel played a critical role in the ability to design longer spans and minimize reconstruction. ABC, design-build and structural steel were the perfect match for this prominent Interstate overpass. ■

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